# RASL System Overview

Design Goal: To develop an airborne mission-adaptable instrument capable of high performance day and night time measurements of water vapor, aerosol, and cloud properties

Base-line instrument measurements (using a tripled Nd:YAG transmission source) :

Raman channels
1. 408 nm: Water Vapor
2. 402 nm: Liquid Water
3. 387 nm: Nitrogen
4. 375 nm: Oxygen

Aerosol channels
5. 355 nm: Total
6. 355 nm: S-polarization
7. 355 nm: P-polarization

# RASL Instrument Diagram

## Optical Trasmission (Red)

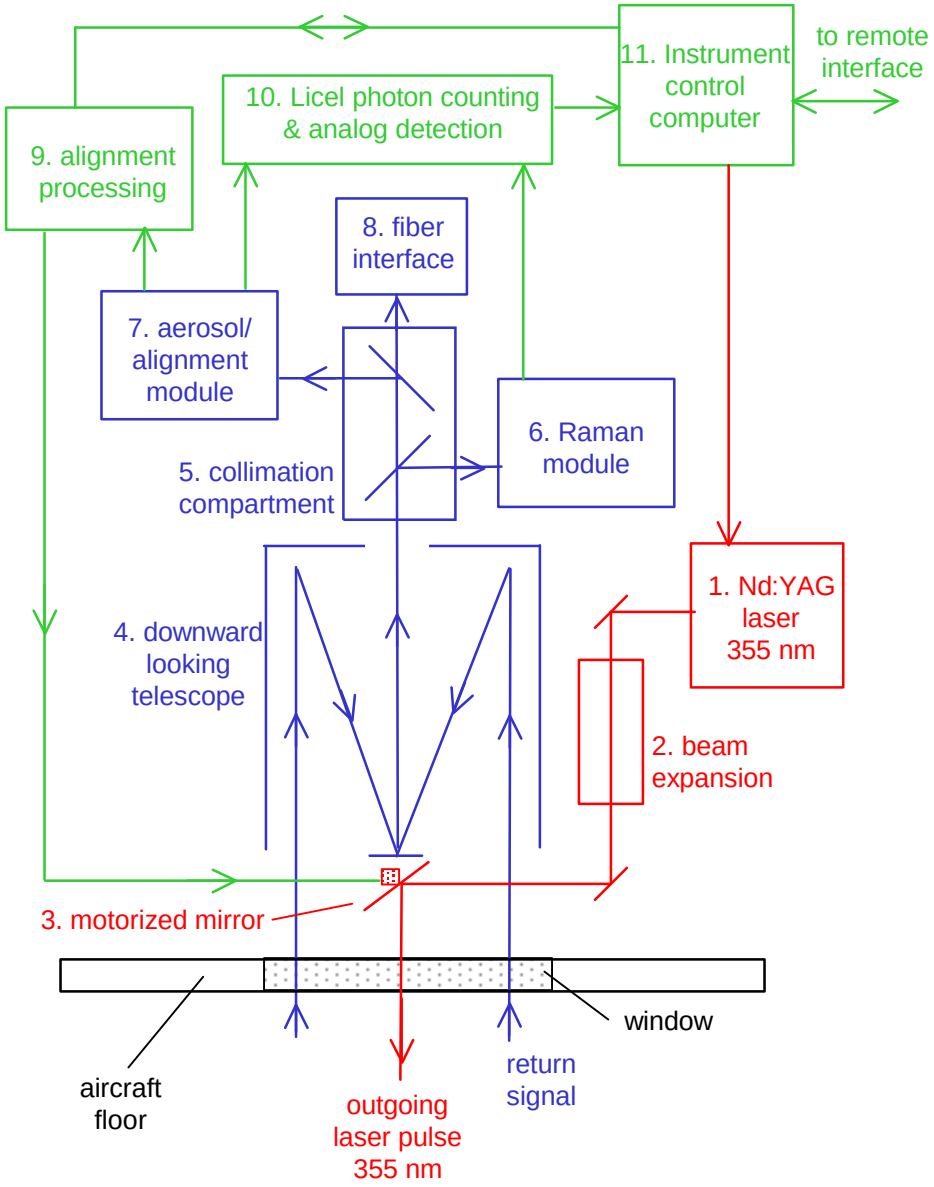
1. Nd:YAG source, > 15 Watts (50 Hz, 300 mJ UV pulses
2. Beam expander, 40 mm diam output, 125 micro-rad divergence
3. Motorized transmit mirror

## Optical Receiver (Blue)

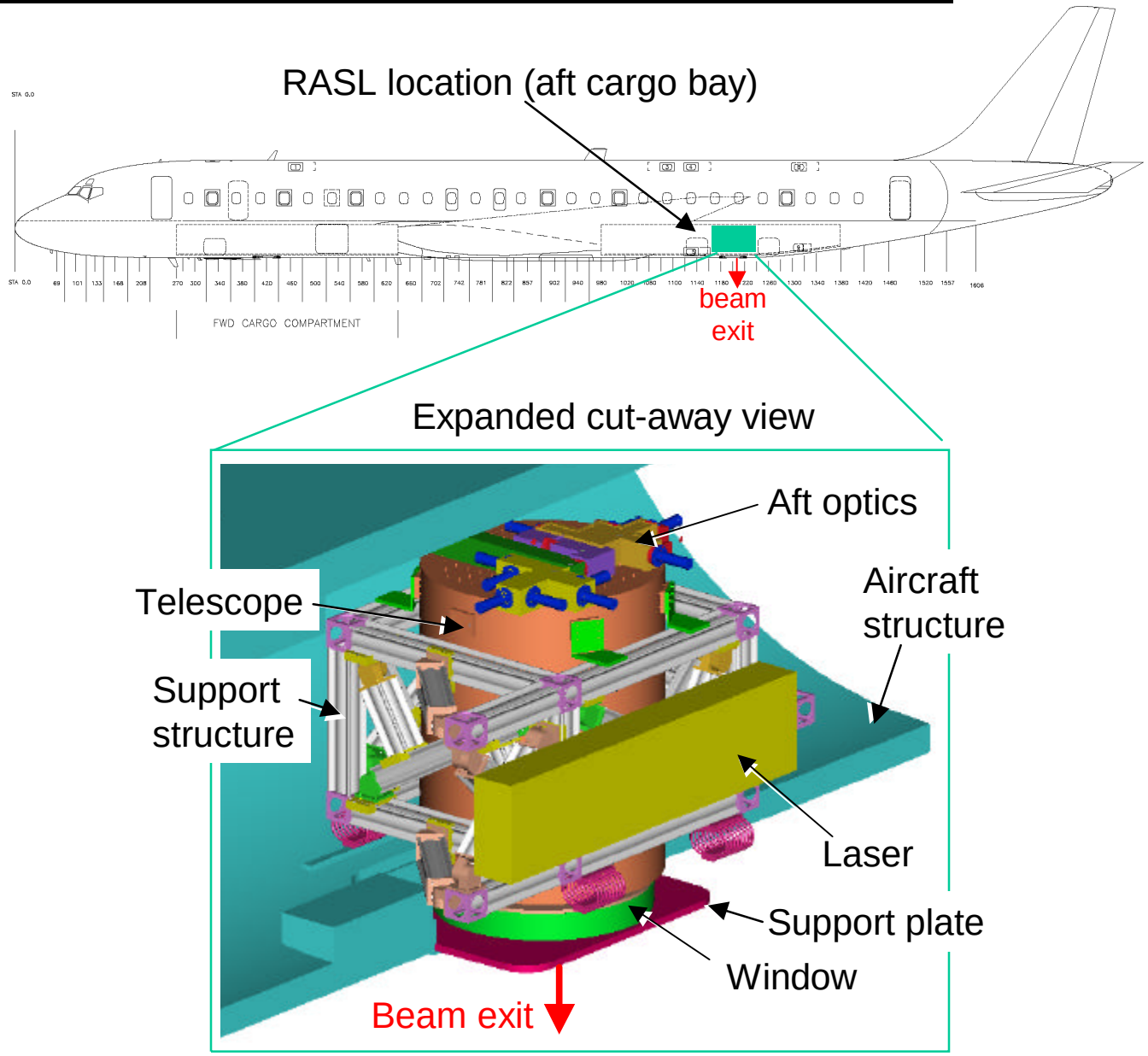
4. Downward looking telescope, 61 cm diam. Dall-Kirkam design, fl= 323 cm
5. Collimation compartment, adjustable FOV & focus, dichroic beam splits
6. Raman Module, Water Vapor, Liquid Water, Nitrogen, & Oxygen detection
7. Aerosol/Alignment module, Total, S & P polarization detection
8. Fiber interface for spectrometer/etalon option

## Data Acquisition & Control (green)

9. Alignment signal processing and feedback to motorized mirror
10. Licel acquisision of PMT signals from Aerosol and Raman modules
11. Main instrument CPU to control



# RASL Implementation on the NASA DC-8



# Aft Optics Key Design Criteria

- Measurements:

  Raman: $H_2O$ liquid&vapor, $N_2$, Aerosol, & Oxygen

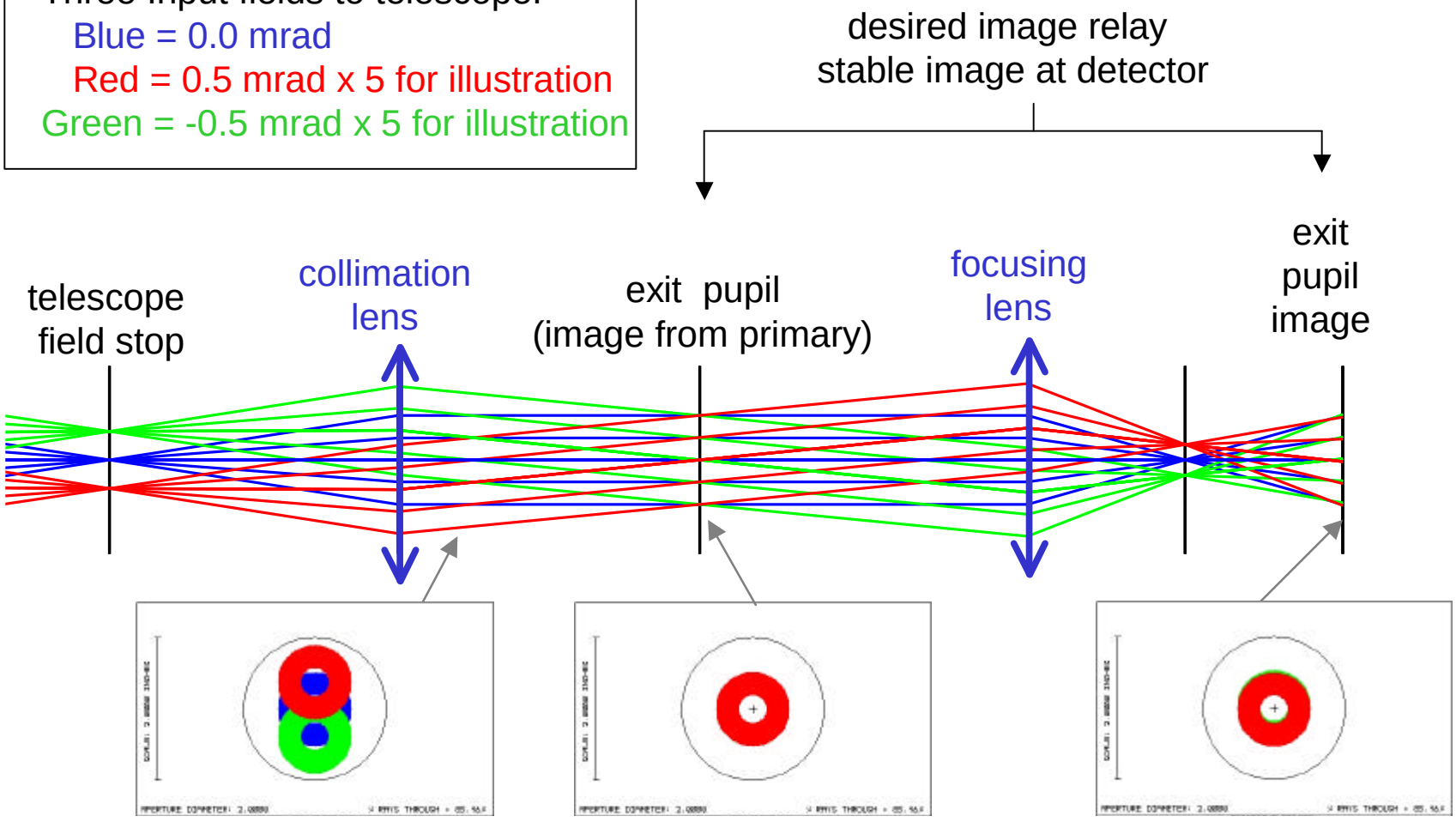
  Aerosol: Total intensity,  S & P polarizations with hi/low power splits

  Interface  for spectrometer/etalon

- Adjustable Focus (2 km to Infinity) & field of view (0.2 to 1 mrad)
- High degree of collimation ( < 14 mrad) needed for bandpass filters
- Image stability at detector for different field angles
- Multi-channel matched optical path lengths
- Laser alignment system to maintain boresite during flight
- Removable filters in flight
- Modular design

# Single-Channel Aft Optics Paraxial Raytrace

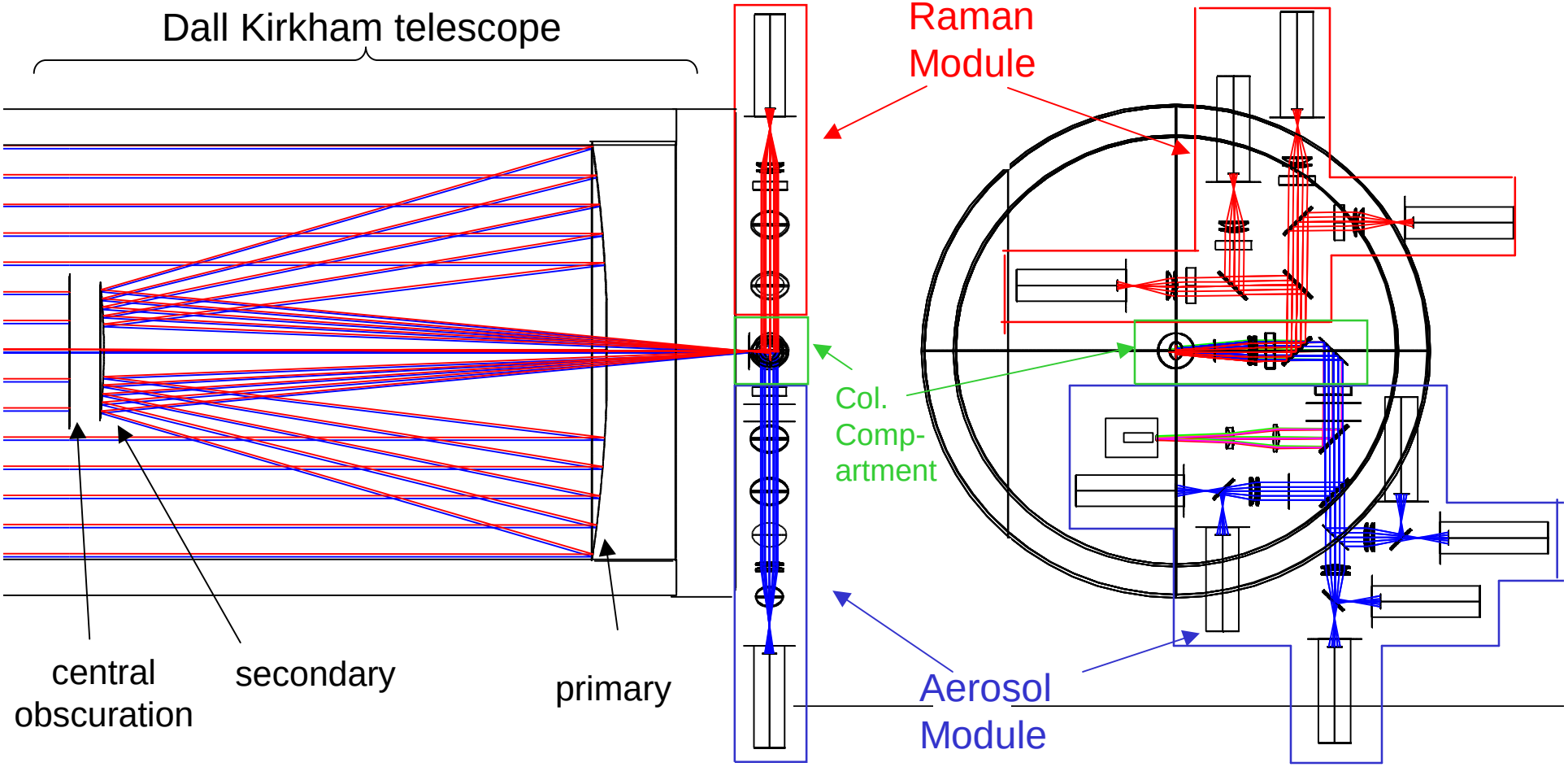
Three Input fields to telescope:
Blue = 0.0 mrad
Red = 0.5 mrad x 5 for illustration
Green = -0.5 mrad x 5 for illustration



# RASL Receiver: Geometrical Raytrace Model

## SIDE VIEW

## END VIEW



# Collimation Compartment Raytrace

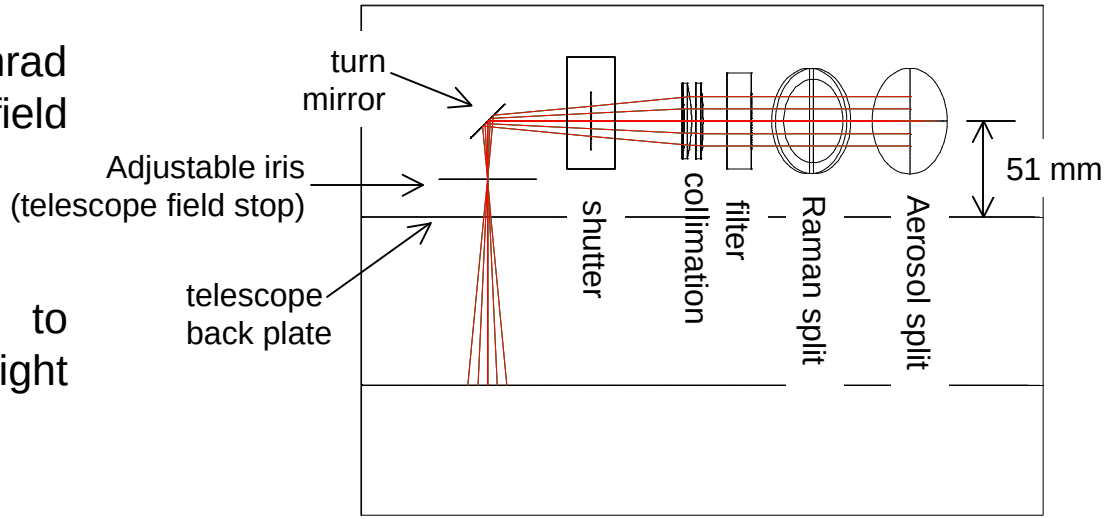
- Field of view from 0.2 to 1 mrad obtained by adjustable iris at field stop

- Focus adjustment from 2 km to infinity by changing optic axis height with specially designed spacers

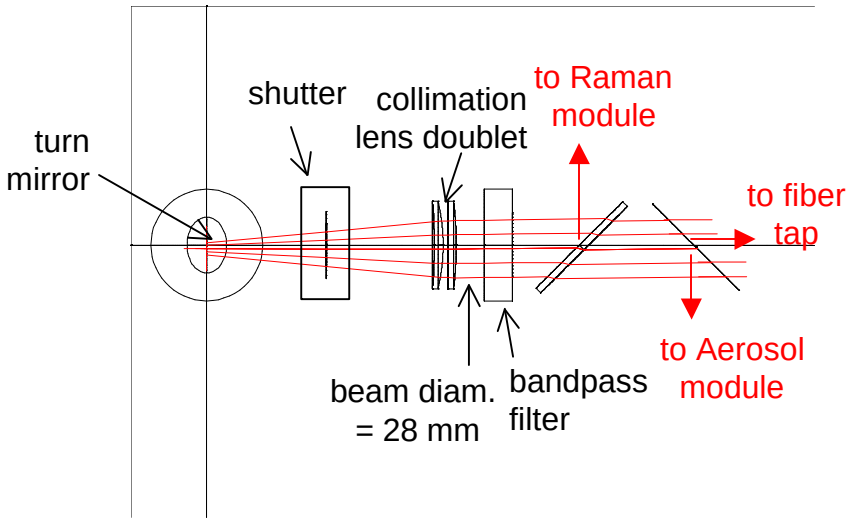
- Collimation < 14 mrad for most extreme telescope field angles (+/- 0.5 mrad) to obtain > 92% transmission through 0.2 nm nm bandpass filters

- Light can be directed into three different locations: 1) Raman module 2) Aerosol/Alignment Module 3) Spectrometer/etalon fiber interface

SIDE VIEW




TOP VIEW

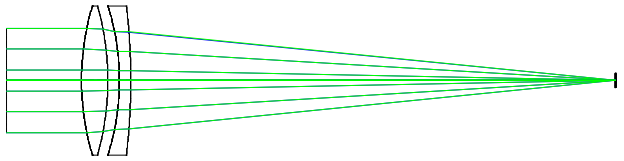


# Custom RASL Collimation Optics: Spot Size Performance

Two different 140 mm focal length doublets

## Option 1: Silica-F2 doublet

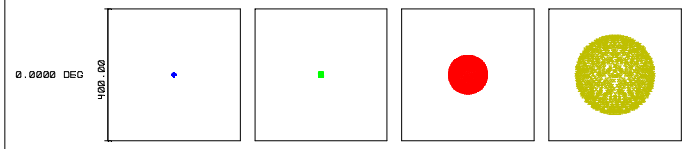
Collimation Optics: Custom Silica-F2 Doublet
(test-plate fit to Special Optics)



SURFACE DATA SUMMARY:

| Surf | Type | Comment | Radius | Thickness | Glass | Diameter | Conic |
|---|---|---|---|---|---|---|---|
| OBJ | STANDARD | | Infinity | Infinity | | 0 | 0 |
| STO | STANDARD | | Infinity | 20 | | 28 | 0 |
| 2 | STANDARD | | 70.76 | 7 | SILICA | 40 | 0 |
| 3 | STANDARD | | -74.01 | 3.1 | | 40 | 0 |
| 4 | STANDARD | | -66.522 | 3 | F2 | 40 | 0 |
| 5 | STANDARD | | -174.14 | 128.961 | | 40 | 0 |
| IMA | STANDARD | | Infinity | | | 3.920535 | 0 |

Focus spot sizes




355 nm
radius= .002 mm
(0.01 mrad)

408 nm
radius= .004 mm
(0.03 mrad)

532 nm
radius= .054 mm
(0.4 mrad)

608 nm
radius= .117 mm
(0.8 mrad)

SURFACE: IMA

MATRIX SPOT DIAGRAM

LENS HAS NO TITLE.
WED AUG 30 2000 UNITS ARE MICRONS.

BOX WIDTH : 400 REFERENCE : CHIEF RAY

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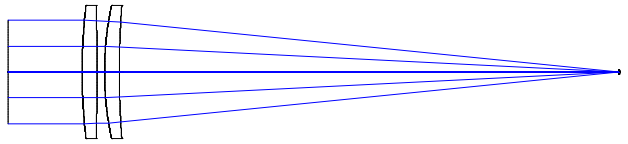
CONFIGURATION 1 OF 1

## Option 2: Fused silica doublet

Collimation Optics: Custom Silica-Silica Doublet
(test plate fit to Special Optics)

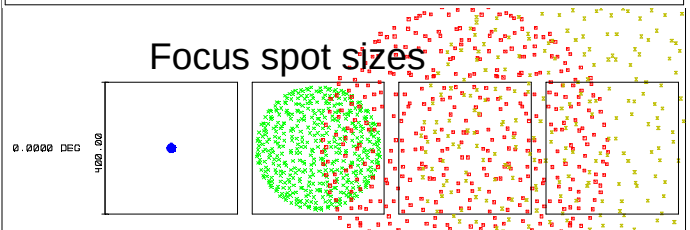
Lens spacing 2 +/- 0.025 mm, 36 mm clear aperture



SURFACE DATA SUMMARY:

| Surf | Type | Comment | Radius | Thickness | Glass | Diameter | Conic |
|---|---|---|---|---|---|---|---|
| OBJ | STANDARD | | Infinity | Infinity | | 0 | 0 |
| STO | STANDARD | | Infinity | 20 | | 30 | 0 |
| 2 | STANDARD | | 159.79 | 4 | SILICA | 40 | 0 |
| 3 | STANDARD | | -811.91 | 2 | | 40 | 0 |
| 4 | STANDARD | | 86.72 | 4 | SILICA | 40 | 0 |
| 5 | STANDARD | | 250.81 | 134.2298 | | 40 | 0 |
| IMA | STANDARD | | Infinity | | | 1.237654 | 0 |

Focus spot sizes




355 nm
radius= .011 mm
(0.08 mrad)

408 nm
radius < 0.2 mm
(1.4 mrad)

SURFACE: IMA

MATRIX SPOT DIAGRAM

LENS HAS NO TITLE.
WED AUG 30 2000 UNITS ARE MICRONS.

BOX WIDTH : 400 REFERENCE : CHIEF RAY

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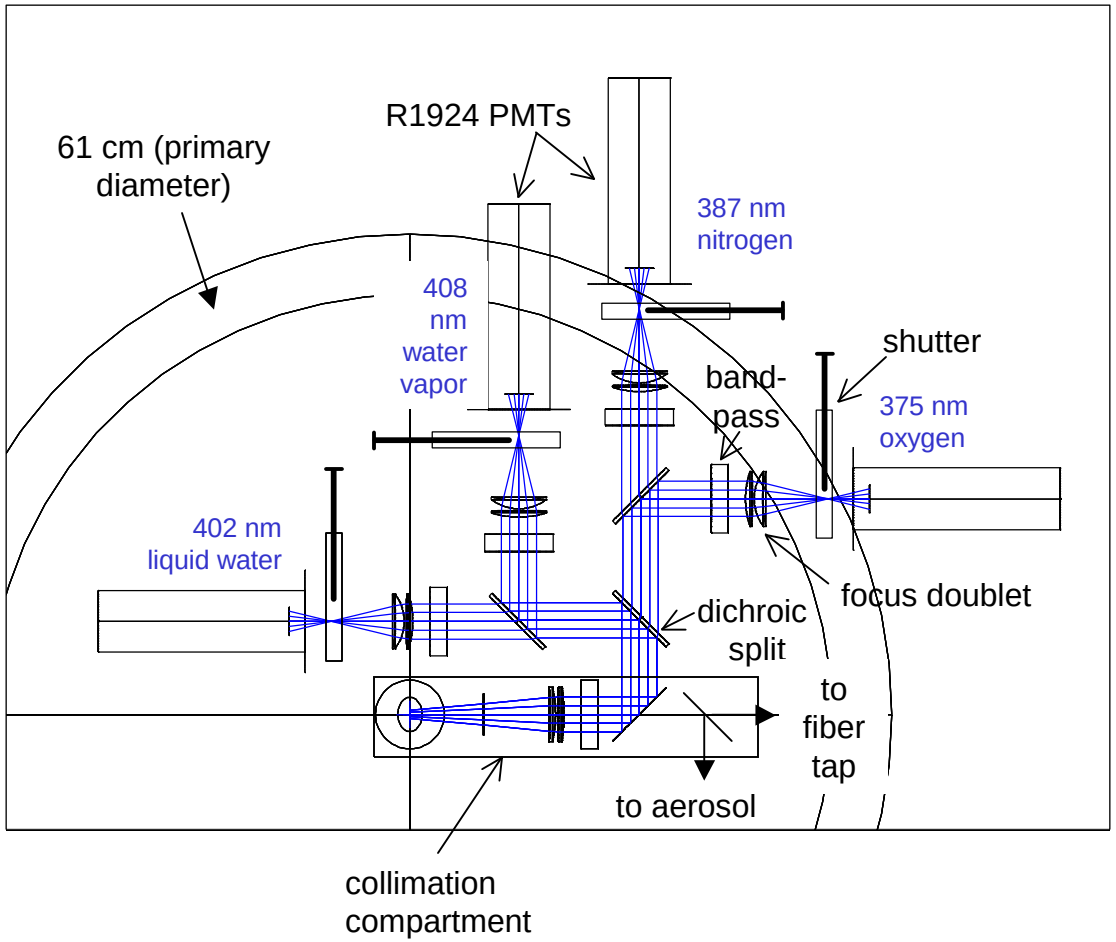
CONFIGURATION 1 OF 1

# RASL Raman Module Raytrace Detail

- Dichroic mirrors used to separate $H_2O$ vapor, $H_2O$ liquid, Oxygen, and Nitrogen wavelengths

- High performance bandpass filters used to isolate spectral line of interest

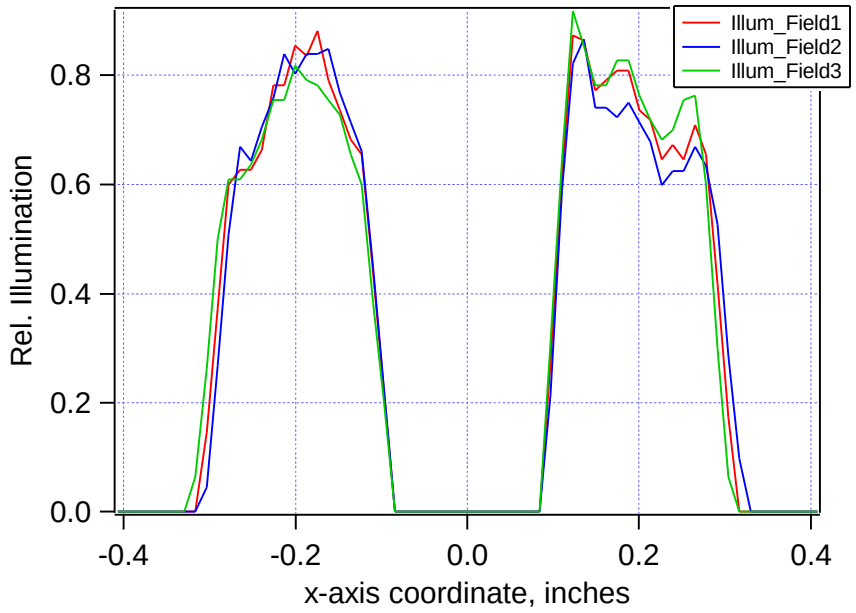
- Custom focusing optics designed to image the telescope exit pupil onto the PMT surface



# Raytrace Simulation Raman PMT image

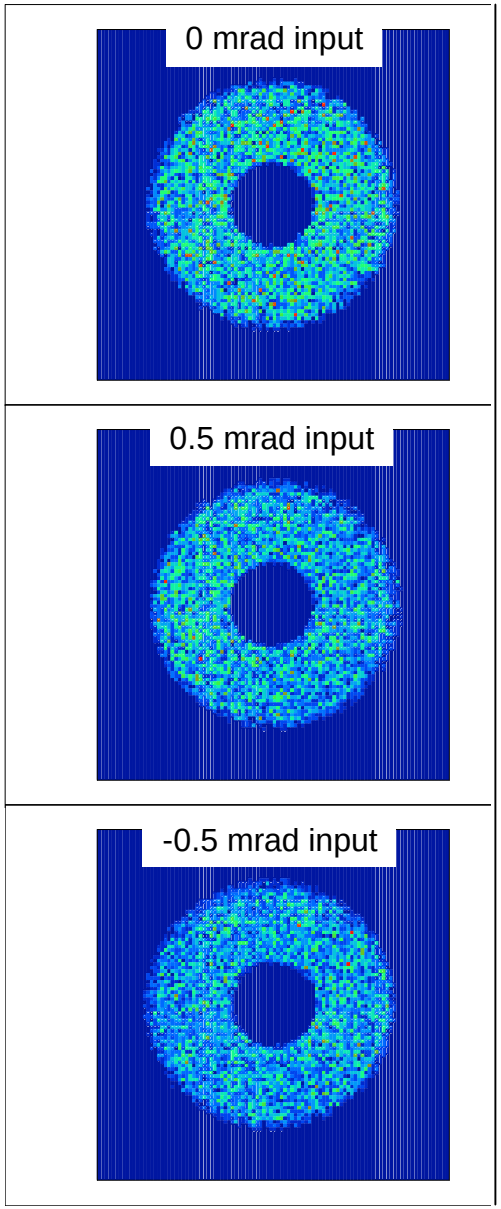
0, +/- 0.5 mrad input fields to telescope

X-axis illumination plots




Spatial movement of image is minimized for extreme ray angle fields

2-D Images at Detector



# RASL Aerosol/Alignment Module Raytrace Detail

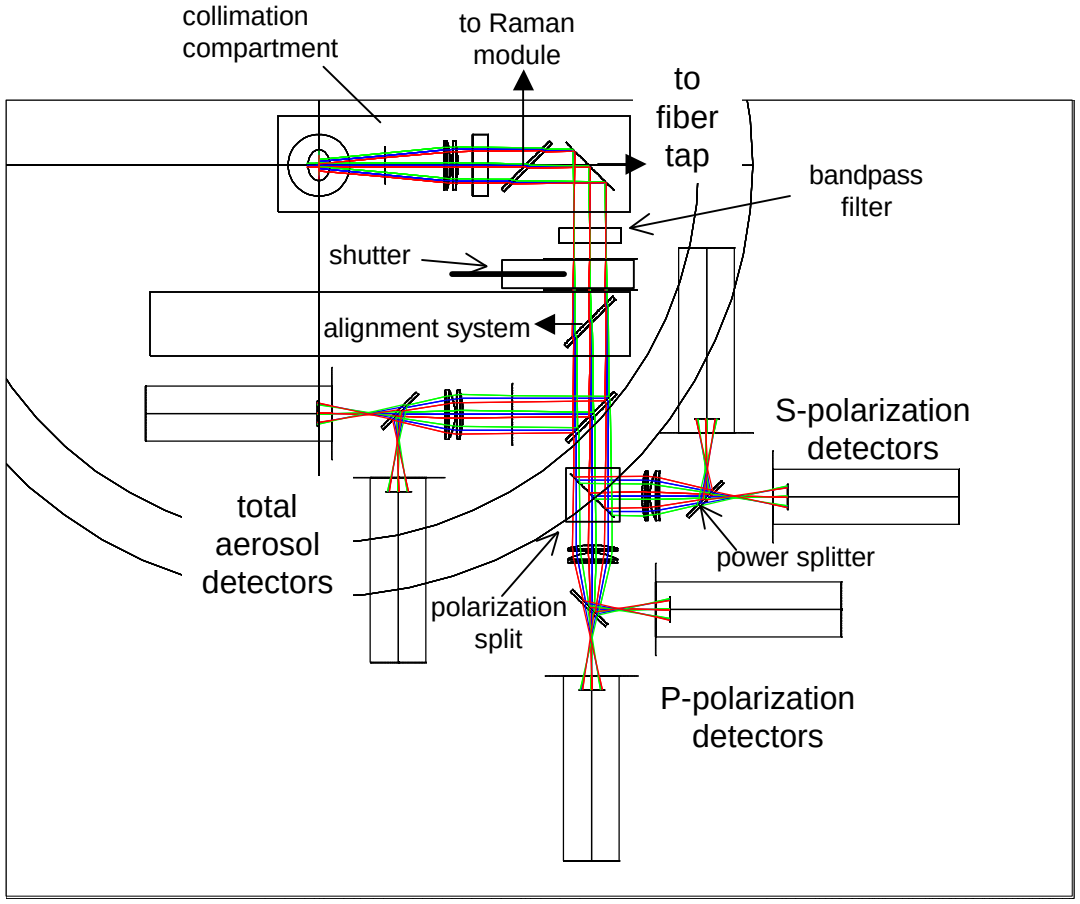
•High performance bandpass filter first used to isolate 355 nm light

•Fraction of light then split off for alignment system

•Remaining light then divided into three polarization channels: 1) total 2) P-state 3) S-state

•Two PMTs are used for each channel to maximize dynamic range

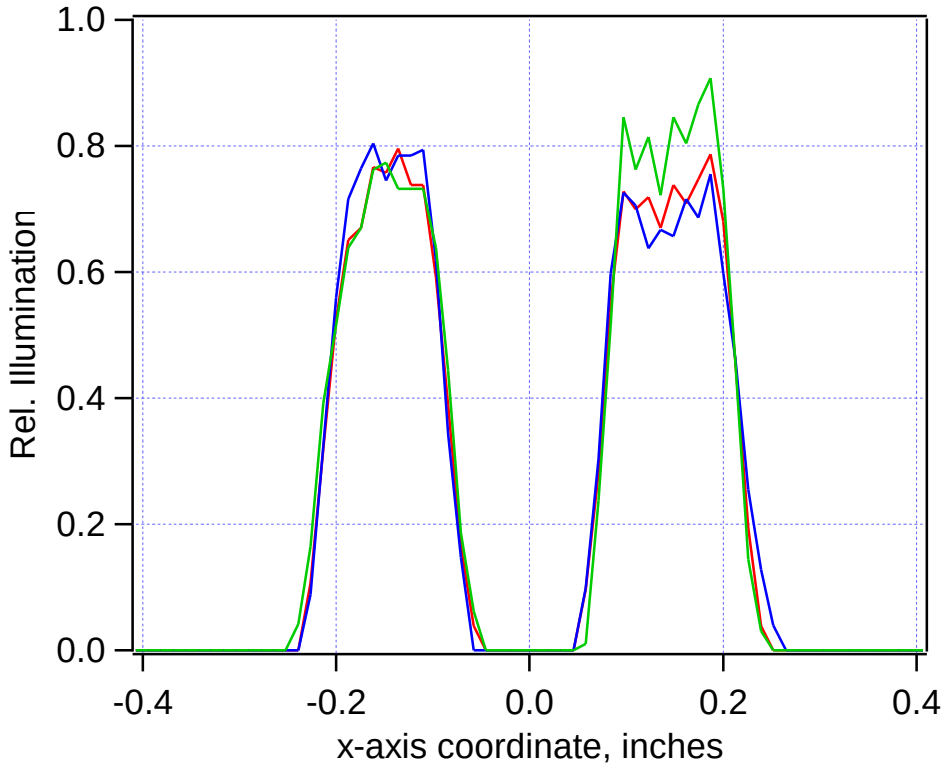
•Custom focusing optics designed to image the telescope exit pupil onto the PMT surface



# Raytrace Simulation Aerosol PMT image

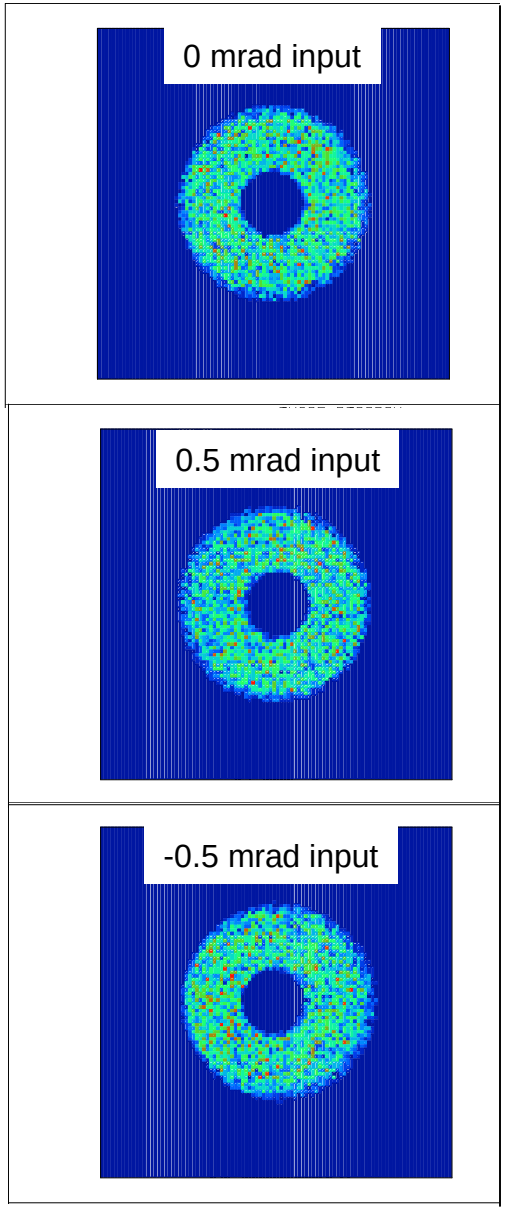
0, +/- 0.5 mrad input fields to telescope

X-axis illumination plots




Spatial movement of image is minimized for extreme ray angle fields

2-D Images at Detector



# RASL Alignment System

• 355 nm light is imaged from telescope field stop to quad detector

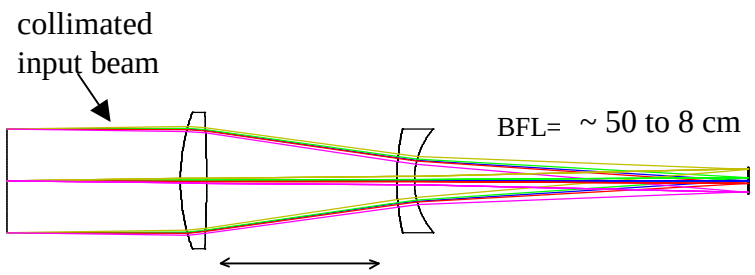
•Movement of bore-site translates laser spot movement across detector quadrants

• Bore-site laser position can then be determined and corrected with active feedback to motorized transmit mirror

• Variable lens spacing to change magnification by 5x thus maximum field angle can be adjusted from 0.2 to 1 mrad

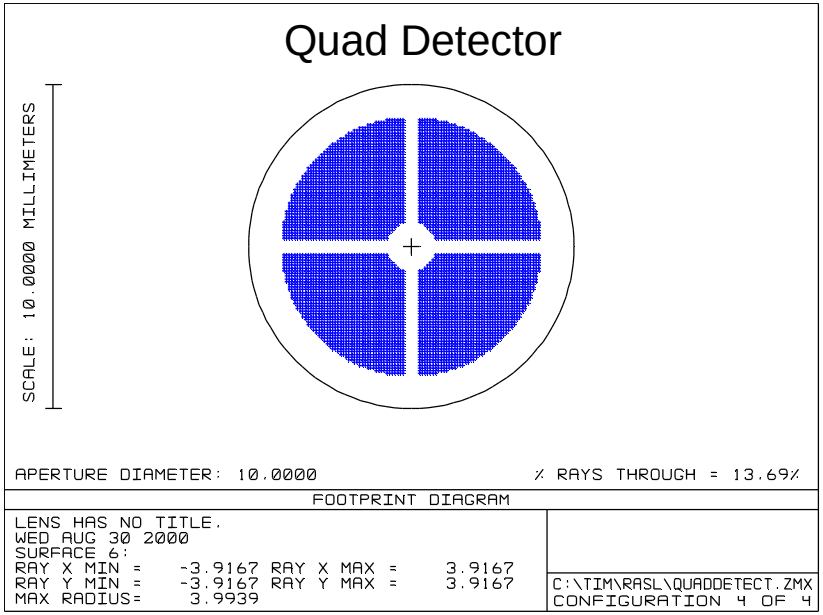
• Adaptable for two different configurations: 1) Quad PMT 2) Quad fiber bundle

Alignment Module Optics for Quad PMT




SURFACE DATA SUMMARY:

| Surf | Type | Comment | Radius | Thickness | Glass | Diameter | Conic |
|---|---|---|---|---|---|---|---|
| OBJ | STANDARD | | Infinity | Infinity | | 0 | 0 |
| STO | STANDARD | | Infinity | 2 | | 1.2 | 0 |
| 2 | STANDARD | | 2.345526 | 0.3 | SILICA | 1.5748 | 0 |
| 3 | STANDARD | | -16.68866 | 2.2 | | 1.5748 | 0 |
| 4 | STANDARD | | 2.860461 | 0.2 | SILICA | 1.2 | 0 |
| 5 | STANDARD | | 0.9281895 | 3.85 | | 1.2 | 0 |
| IMA | STANDARD | | Infinity | | | 0.315 | 0 |



# RASL Aft Optics: current status

- Aft optics design complete for base-line Raman and Aerosol measurement channels; 3-D multi-channel geometrical ray-trace model used to analyze optical properties of all measurement channels

- Design addresses the criteria established for high performance Raman and Aerosol measurements

- All custom lens doublets for base-line measurement channels are currently being fabricated by Special Optics, Inc. with expected delivery in two months

- All dichroic splitters, power splitters, and polarization optics have been specified and are on order with expected delivery in Q4

- Alignment system design currently in process, optics to be purchased by by end of Q3, delivery expected by Q4